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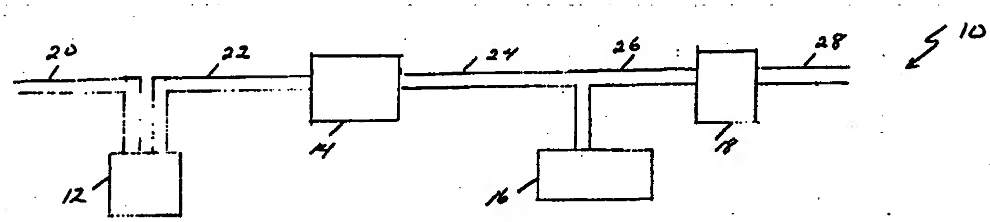

(57) Abstract

The invention provides a water treatment and storage system (10). The system (10) includes a pre-filter (12), an intermediate-filter (14), and a post-filter (18) each having a filter medium. At least one of the filter mediums is impregnated with a bacteria limiting material. The pre-filter (12), the intermediate-filter (14), and the post-filter (18) are coupled together such that there is a system fluid flow path (20, 22, 24, 26, 28) passing through the pre-filter (12), the intermediate filter (14) and the post-filter (18), and exiting through the second port of the post-filter (18). The system (10) also has a fluid storage tank (16) having an interior region of the tank (16) and a bi-directional fluid passage port fluidly coupled between the interior region of the tank, the output port of the intermediate-filter (14) and the second port of the post-filter (18). The invention also provides a method of treating and storing water using such a system (10). The invention further provides a drinking water polishing system and a water polishing system employing layered filtration media, where each of the systems contains a bacteria limiting material.

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BACTERIA LIMITING WATER TREATMENT AND STORAGE SYSTEMS AND METHODS

FIELD OF THE INVENTION

This invention relates to the field of water treatment, and in particular to the limitation of bacteria in process or potable drinking water.

BACKGROUND OF THE INVENTION

Water treatment devices for removal of mineral, total dissolved solids (TDS) and other physical-chemical contaminants are known in the art. In many cases, however, water treatment devices and/or water storage tanks become contaminated with germs, bacteria and other biological growth which may infest the treated water. For example, it is reported that heterotrophic bacteria growth is amplified in granulated activated carbon water treatment filters and in hot water tanks. Denn, J., *Heterotrophic Menace: fact or fiction,* Water Technology 54, 55 (February 1999). Such heterotrophic bacteria may cause gastrointestinal illness and pneumonia in some people.

Different methods have been proposed to combat biological growth in water treatment and storage systems. For example, one proposed option includes the more frequent replacement of carbon filters. More frequent filter replacement may incur increased labor and equipment costs. Further, more frequent filter replacement may cause operational inconvenience.

Another proposed option is the more frequent flushing of water treatment and storage systems. Such an option may also incur increased costs as well operational inconvenience, as discussed above.

Still another proposed option to combat biological growth in water treatment and storage systems is the sanitation of water treatment and storage devices with sanitizing materials. Undesirable disinfection by-products can result from the addition of such sanitizing materials, however. For example, chlorine

may react with organics in water to produce chlorinated organics which may be carcinogenic. Further, sanitizing materials such as, for example, chlorine, may shorten the life of certain water treatment membranes and ion exchange resins used for treating potable and process water, however.

Accordingly, it is an object of this invention to retard, to reduce, to inhibit and/or to eliminate biological growth including, for example, bacterial growth, in water treatment and storage systems without unduly complicating or adversely affecting the water treatment devices and/or the water treatment and storage process.

SUMMARY OF THE INVENTION

In one embodiment, the invention provides a water treatment and storage system. The system includes a pre-filter having an input port and an output port fluidly coupled by way of a pre-filter filter medium; an intermediate-filter having an input port and an output port fluidly coupled by way of an intermediate-filter filter medium; and a post-filter having a first port and a second port fluidly coupled by way of a post-filter filter medium. The pre-filter, the intermediate-filter, and the post-filter are coupled together such that there is a system fluid flow path passing through the pre-filter, the intermediate filter and the post-filter, and exiting through the second port of the post-filter. The system also has a fluid storage tank having an interior region of the tank and a bi-directional fluid passage port fluidly coupled between the interior region of the tank, the output port of the intermediate-filter and the second port of the post-filter. At least one of the pre-filter filter medium, the intermediate-filter filter medium, and the post-filter filter medium contain a bacteria limiting material.

As used herein, the term "bi-directional fluid passage port" refers to a port assembly which permits flow into and out of a fluid storage tank. Such a port assembly includes both a singular bi-directional port or alternatively, one or more input ports and one or more output ports.

As used herein, the term "bacteria limiting material" refers to material which limits biological growth.

As used herein, the term "to limit or limit(s) biological growth" refers to the retarding, reduction, inhibition and/or elimination of biological growth.

As used herein, the term "biological growth" includes the growth of microorganisms such as, for example, bacteria including aerobic and anaerobic bacteria, viruses and/or algae.

In another embodiment, the intermediate-filter, the post-filter and the storage tank of the above-described water treatment and storage system are fluidly coupled together such that the system flowpath passes from the output port of the intermediate-filter through the storage tank fluid passage port to and subsequently from the interior region of the fluid storage tank, the first port of the post filter and the post-filter filter medium, and exits through the second port of the post-filter.

In still another embodiment of the invention, the intermediate filter, the post-filter and the storage tank of the above-identified water treatment and storage system are fluidly coupled together such that the system flowpath passes from output port of the intermediate-filter through the second port of the post-filter, the post-filter medium, the first port of the post-filter, the storage tank fluid passage port to and subsequently from the interior region of the fluid storage tank, the first port of the post-filter and the post-filter filter medium, and exits through the second port of the post-filter.

In yet another embodiment, the invention provides the above-described water treatment and storage system including a first post-filter sub-unit having a first sub-port and a second sub-port fluidly coupled by way of a first post-filter sub-unit filter medium; and a second post-filter sub-unit having a first sub-port and a second sub-port fluidly coupled by way of a second post-filter sub-unit filter medium. The intermediate-filter, the first post-filter sub-unit, the second post-filter sub-unit and the storage tank are fluidly coupled together such that the system flowpath passes from the output port of the intermediate-filter through the first sub-port of the first post-filter sub-unit, the first post-filter sub-unit filter medium, the second sub-port of the first post-filter sub-unit, the storage tank fluid passage port to and subsequently from the interior region of the fluid storage tank, the first sub-port of the second post-filter sub-unit and the second post-filter sub-unit filter

medium, and exits through the second sub-port of the second post-filter sub-unit.

In a further embodiment, the invention provides a drinking water polishing system including at least two water treatment units. Each unit in turn includes a base and a replaceable cartridge. The replaceable cartridge of the first unit includes a depth filter adapted to remove from water flowing therethrough particles having sizes in the range from about 1 to about 1000 micrometers. Down-stream from the depth filter, the cartridge includes silvered, granular, activated carbon characterized by releasing into water flowing therethrough soluble silver in the range from about 5 to about 90 micrograms per liter. Downstream from the first unit, the system includes at least one additional unit. This second unit includes a replaceable cartridge which has at least one component selected from the group of components consisting of:

> microporous carbon filtration blocks, silvered microporous carbon filtration blocks, granular activated carbon, silvered granular activated carbon, ultrafiltration membranes, nanofiltration membranes, reverse osmosis membranes, microfiltration membranes, chelating cation exchange resin, strong acid cation exchange resin, weak acid cation exchange resin, strong base anion exchange resin, weak base anion exchange resin, macroporous anion exchange resin, granular absorbents, iodinated ion-exchange resin and specialized lead removal media.

In still a further embodiment, the invention provides a drinking water polishing system including at least a first water treatment unit having a first cartridge and a base. The first cartridge has a depth filter adapted to remove from water flowing therethrough particles having sizes in a range from about 1 to about 1000 micrometers. Down-stream from the depth filter in the first cartridge, the first cartridge has a first filter component. The system also includes at least one additional second water treatment unit. The second unit has a second cartridge and a base. The second cartridge has at least one second filter component. At least one of the first and the second filter components is impregnated with a bacteria limiting

material.

The invention also provides a method of treating and storing water. The method includes the steps of passing water through a pre-filter having an input port and an output port fluidly coupled by way of a pre-filter filter medium; passing water through an intermediate-filter having an input port and an output port fluidly coupled by way of an intermediate-filter filter medium; and passing water through a post-filter having a first port and a second port fluidly coupled by way of a post-filter filter medium. The pre-filter, the intermediate-filter, and the post-filter are coupled together such that there is a system fluid flow path passing through the pre-filter, the intermediate filter and the post-filter, and exiting through the second port of the post-filter. The method also includes the step of storing the water in a fluid storage tank having an interior region of the tank and a bi-directional fluid passage port fluidly coupled between the interior region of the tank, the output port of the intermediate-filter and the second port of the post-filter. At least one of the pre-filter filter medium, the intermediate-filter filter medium, and the post-filter filter medium contains a bacteria limiting material.

BRIEF DESCRIPTION OF THE DRAWINGS

For a fuller understanding of the nature and the objects of the invention, reference should be made to the following detailed description and the accompanying drawings in which like reference numerals refer to like elements and in which:

FIG. 1 shows a water treatment and storage system pre-filter impregnated with a silver bacteria limiting material.

FIG. 2 shows a water treatment and storage system intermediate-filter impregnated with a silver bacteria limiting material.

FIG. 3 shows a water treatment and storage system post-filter impregnated with a silver bacteria limiting material.

FIG. 4 shows a flow diagram of a single pass post-filter water treatment and storage system;

FIG. 5 shows a schematic representation of a single pass post-filter water

treatment and storage system;

FIG. 6 shows a flow diagram of a dual pass post-filter water treatment and storage system;

FIG. 7 shows a schematic representation of a dual pass post-filter water treatment and storage system;

FIG. 8 shows a flow diagram of a twin post-filter water treatment and storage system;

FIG. 9 shows a schematic representation of a twin post-filter water treatment and storage system;

FIG. 10 shows a schematic representation of a drinking water polishing system; and

FIG. 11 shows a schematic representation of a water polishing system for a closed loop system; and

FIG. 12 shows a water treatment and storage intermediate filter including graded density filtration media layers.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The invention provides systems and method for the storage and treatment of potable and process water partially or substantially to remove minerals, TDS and/or other physical-chemical contaminants from the treated water, and to limit biological growth in the effluent water and/or in the water treatment devices.

The invention also provides drinking water polishing systems including bacteria limiting materials.

The invention further provides water polishing systems and water treatment and storage systems including graded density filtration media layers wherein the first filtration media layer includes a bacteria limiting material.

I. Water Treatment and Storage Systems

In one embodiment, the water and treatment storage system of the invention includes a pre-filter having an input port and an output port fluidly coupled by way of a pre-filter filter medium; an intermediate-filter having an input port and an output port fluidly coupled by way of an intermediate-filter filter medium; and a

post-filter having a first port and a second port fluidly coupled by way of a post-filter filter medium. An exemplary pre-filter, intermediate-filter and post-filter are illustrated in FIGS. 1, 2 and 3, respectively.

The pre-filter, the intermediate-filter, and the post-filter are coupled together such that there is a system fluid flow path passing through the pre-filter, the intermediate filter and the post-filter, and exiting through the second port of the post-filter. The system also has a fluid storage tank having an interior region of the tank and a bi-directional fluid passage port fluidly coupled between the interior region of the tank, the output port of the intermediate-filter and the second port of the post-filter. At least one of the pre-filter filter medium, the intermediate-filter filter medium, and the post-filter filter medium contain a bacteria limiting material.

Different configurations of the water treatment and storage systems are described below as a Single Pass Post-Filter System, a Dual Pass Post-Filter System and a Twin Post-Filter System. Modifications of the following system configurations known to those of ordinary skill in the art are possible. In one non-limiting example, the following systems can be modified to include one or more additional ports for mineral rejection from one or more of the filters.

A. Single Pass Post-Filter System

The invention provides, in one embodiment, a water treatment and storage system 10, such as a Single Pass Post-Filter System, as illustrated in FIGS. 4 and 5. The system 10 includes a pre-filter 12, an intermediate-filter 14, a storage tank 16 and a post filter 18. Incoming fluid 20 passes through the pre-filter 12 to form an output stream 22. The output stream 22 then inters the intermediate-filter 14 where it is further treated and the effluent stream 24 from the intermediate-filter passes into the storage tank 16 where it may be held for variable lengths of time. The effluent 22 stream from the storage tank 26 passes into a post-filter 18 for further treatment. Effluent 28 from the post-filter then exits the system 10 to its point of use. The overall system flow path is thus illustrated by fluid streams 20, 22, 24, 26 and 28.

A more detailed illustration of a Single Pass Post-Filter System 30 is illustrated in FIG. 5. In FIG. 5, incoming fluid 40 passes into a pre-filter 32

through an input port 52. The fluid travels through a filter medium 56 to an output port 54. The fluid stream 42 exiting the output port 54 of the pre-filter 32 passes into an intermediate-filter 34 through an input port 62. The fluid is filtered through a filter membrane 66 to an output port 64. The effluent stream 44 from the intermediate filter 34 passes through a fluid passage port 92 into an interior region 94 of a storage tank 36 where it may be held for variable lengths of time. The effluent fluid 46 from the storage tank 36 then passes out of the interior region 94 of the storage tank 36 though the storage tank fluid passage port 92 through a first port 72 into the post-filter 38. The fluid is filtered through filter medium 76 to a second port 74. The effluent stream 48 exits the system 30 through the second port 74 to its point of use.

Either one or a combination of the filter mediums 56, 66, 76 of the pre-filter 32, the intermediate-filter 34 and the post-filter 38, respectively, include a filter medium impregnated with a bacteria limiting material. For example, such a medium can include activated carbon in either a granulated or microporous solid block extruded form. Preferably, the filter medium, such as, for example, activated carbon, is adapted to remove from water flowing therethrough particles having sizes in the range from about 1 to about 1000 micrometers.

The filter medium can remove odor, color, and colloidal and soluble organics including halogenated organics resulting in, for example, a municipal water treatment plant. Some of such halogenated organics are believed to be carcinogenic. The filter medium can also remove dissolved disinfectants such as chlorine from the water passing therethrough. Accordingly, the filter mediums of the invention can enhance the flavor or the water passing therethrough by removing any stale or unpleasant tastes. The filter medium in the post-filter can be used to adjust the pH of the effluent water and such adjustment can be used to address potentially corrosive water conditions in the downstream systems employing the treated water.

The bacteria limiting material contained in one or a combination of the filter mediums of the pre-filter, the intermediate-filter and the post-filter limits biological growth. FIG. 5 illustrates the pre-filter 32, the intermediate-filter 34 and the post-

filter each containing a bacteria limiting material 82, 84, and 86, respectively.

Non-limiting examples of a bacteria limiting materials which can be used with the present invention include iodinated ion-exchange resins or oligo-dynamic metals such as, for example, silver and copper. Preferably silver is used in the present invention. Silver can be contained within activated carbon, such as in, for example, Hygene ® made by Ionics, Inc., Bridgeville, Pennsylvania. Silvered carbon performs by releasing silver ions into the water. The silver ions limit the growth of microorganisms which are in the water or have been captured by the carbon. Preferably, the silvered carbon used in the invention contains between about .01% to about 10% carbon.

In addition to or in lieu of granular or extruded block carbon with or without bacteria limiting material, the filter medium 66 of the intermediate filter 34 can include one or a combination of ultrafiltration membranes, nanofiltration membranes, reverse osmosis membranes, microfiltration membranes, and microporous ceramic filtration blocks. Non-limiting examples of materials which can be used for making such membranes are found in U.S. Patent Serial Number 4,735,717 by K. Sims. The nanofiltration membranes and reverse osmosis membrane respectively remove some or most of minerals in the water passing therethrough. Accordingly, the intermediate filter 34 employing such membranes is equipped with a small bleed controlled by a back pressuring device or valve known to those of ordinary skill in the art to allow such minerals to pass to a drain.

Preferably, the microporous ceramic and carbon filtration blocks used in the invention have pore sizes of about 1 micrometer or less.

The type of sorbent used in the membranes depends upon the type of contaminants to be removed. Accordingly, in combination with, in addition to or in lieu of the membranes, the filter medium 66 can also include one or more of chelating cation exchange resins, strong acid cation exchange resins, weak acid cation exchange resins, strong base anion exchange resins, weak base anion exchange resins, macroporous anion exchange resins, iodinated resins, granular absorbents and specialized lead removal media.

Non-limiting examples of such sorbents as well as a description of which

resins and what forms of such resins are bacteriostatic are found in U.S. Patent Serial No. 4,735,717 by K. Sims.

A non-limiting example of iodinated resins which can be used with the present invention includes PentaPure ® resins made by PentaPure, Incorporated, West St. Paul, Minnesota. Such ion exchange resins are pre-treated to absorb and hold iodine. When water passes through such material, the resins have a bacteriocidal effect and kill bacteria present in the water.

A non-limiting example of specialized lead removal media which can be used with the present invention includes ATS ® made by Englehard Corp., Iselin, New Jersey. Such material has the ability to remove lead from water.

In embodiments of the invention, the filter medium 66 of the intermediate-filter 34 includes one or a combination of the above-identified membranes, microporous ceramic blocks and/or sorbents in a first component, and a second component impregnated with bacteria limiting material downstream of the first component. The first component removes particular matter which might otherwise plug the bacteria limiting material in the second component.

Preferably each pre-filter 32, intermediate filter 34 and post-filter 38 is replaced as a unit. See, for example, the description of membrane replacement provided in U.S. Patent Serial No. 4,735,717. Alternatively, one or two of the pre-filter 32, the intermediate filter 34 and the post-filter 38 are replaced as a unit.

In other embodiments of the invention, either one or a combination of the filter mediums 56, 66 and 76 of the pre-filter 32, the intermediate filter 34 and the post-filter 38, respectively, are contained in a removable container such as a sac or a stocking which permits ready replacement when the filter medium is exhausted, as described in, for example, U.S. Patent Serial No. 4,735,717. The container must be porous at least in the region in which the fluid passing through the filter medium will be introduced and in the region from which the treated fluid will exit the filter medium. Alternatively, the filter medium can be regenerated in situ, as described in, for example, U.S. Patent Serial No. 4,735,717.

The pre-filter 32, the intermediate-filter 34 and the post-filter 38 are illustrated as cylindrical containers. Other shaped containers known to those of

ordinary skill in the art are possible for use with the invention, however.

Preferably, each of the input ports 52, 62 and the output ports 54, 64 of the pre-filter 32 and the intermediate-filter 34, respectively, and the first port 72 and the second port 74 of the post-filter 38 are of a bayonet-type coupled to a header assembly manifold. Other types of port assemblies known to those of ordinary skill in the art can also be used with the invention, however.

Preferably, the storage tank 36 operates with an elastic bladder known to those of ordinary skill in the art. Hydrostatic pressure provided by the elastic bladder can then drive the water through the post-filter. Other types of storage tanks and pumping components known to those of ordinary skill in the art can also be used with the invention, however.

In embodiments of the invention, the system 30 can include an overall system output valve for varying fluid passing therethrough from the second port 74 of the post-filter 38 to the point of use.

B. Dual Pass Post-Filter System

The invention provides, in another embodiment, a water treatment and storage system 110, such as a Dual Pass Post-Filter System, as illustrated in FIGS. 6 and 7. The system 110 includes a pre-filter 112, an intermediate-filter 114, a storage tank 116 and a post filter 118, as shown in FIG. 4. Incoming fluid 120 is filtered through the pre-filter 112 and exits as output stream 122. The output stream 122 then inters the intermediate-filter 114 where it is further treated and the effluent stream 124 from the intermediate-filter 114 passes into the post-filter 118. The fluid is filtered through the post-filter 118 and exits as output stream 126. The output stream 126 passes into a fluid storage tank 116 where it may be held for variable lengths of time. The effluent 127 stream from the fluid storage tank 126 passes into a post-filter 118 for further treatment. Effluent 128 from the post-filter 118 then exits the system 10 to its point of use.

Accordingly, the Dual Pass Post-Filter System allows fluid 124 exiting the intermediate filter 114 to pass through the post-filter 118 at least once before entering the storage tank 116 and similarly allows fluid 127 exiting the storage tank 116 to make another pass through the post-filter 118 before exiting the system 110.

A more detailed illustration of a Dual Pass Post-Filter System 130 is illustrated in FIG. 6. In FIG. 7, incoming fluid 140 passes into a pre-filter 132 through an input port 152. The fluid is filtered through a pre-filter filter medium 156 to an output port 154. The filtered fluid stream 142 exits the pre-filter 132 through the output port 154 and passes into an intermediate-filter 134 through an input port 162. The fluid is filtered through an intermediate-filter filter membrane 166 to an output port 164. The filtered fluid stream 144 exits the intermediate-filter 134 through the output port 164 and passes into the post-filter 138 through second port 172. The fluid is filtered through the post-filter filter medium 176 and the filtered fluid 146 exits the post-filter 138 through first port 174.

The effluent fluid 147 from the post-filter 138 passes into an interior region 194 of the fluid storage tank 136 though a storage tank fluid passage port 192 where it may be held for variable lengths of time. The fluid exits the interior region 194 of the fluid storage tank 136 through the storage tank fluid passage port 147 and again passes into the post-filter 138 through the first port 174. The fluid is filtered again through the post-filter filter medium 176 and the filtered fluid 148 exits the post-filter 138 through the first port 172. The effluent stream 148 from the post-filter 138 passes from the system 130 to its point of use.

Either one or a combination of the filter mediums 156, 166, 176 of the respective pre-filter 132, the intermediate filter 134 and the post-filter 138 include a filter medium impregnated with a bacteria limiting material. For example, such a filter medium can include activated carbon in either a granulated or a microporous solid block extruded form. Preferably, tthe filter medium, such as, for example, activated carbon, is adapted to remove from water flowing therethrough particles having sizes in the range from about 1 to about 1000 micrometers.

The filter mediums of the Dual Pass Post-Filter System 130 can serve a variety of functions, such as, for example, removing odor, color, and organics, as outlined above in the discussion of filter mediums for the Single Pass Post-Filter System 30.

The bacteria limiting material contained either one or a combination of the filter mediums 156, 166 and 176 of the respective pre-filter 132, the intermediate-

filter 134 and the post-filter 176 limits biological growth. FIG. 7 illustrates the pre-filter 132, the intermediate-filter 134 and the post-filter 138 each containing a bacteria limiting material 182, 184 and 186, respectively.

The non-limiting examples of bacteria limiting materials useful for the Dual Pass Post-Filter System 130 are described above for the Single Pass Post-Filter System 30. Preferably an oligo-dynamic metal, and even more preferably, silver is used as the bacteria limiting material, as described above for the Single Pass Post-Filter System 30.

In addition to or in lieu of activated carbon, the filter medium 166 of the intermediate-filter 134 can include one or more of the membranes, microporous ceramic blocks, and/or sorbents described above for the Single Pass Post-Filter System 30.

In embodiments of the invention, the filter medium 166 of the intermediate filter 134 includes one or a combination of first and second filter components, as described above for the Single Pass Post-Filter System 30.

Preferably, each pre-filter 132, intermediate-filter 134 and post-filter 138 is replaced as a unit or alternatively, one or two of the filters are replaceable as a unit, as described above for the Single Pass Post-Filter System 30. In other embodiments of the invention, one or a combination of the filter mediums 156, 166 and 176 are contained in a removable container, again as described above for the Single Pass Post-Filter System 30.

The pre-filter 132, the intermediate-filter 134 and the post-filter 138 are illustrated as cylindrical containers. Other shaped containers known to those or ordinary skill in the art are possible for use with the invention, however

The input ports 152, 154 and the output ports 162, 164 of the respective pre-filter 132 and the intermediate-filter 134, and the first port 174, and the second port 172 port of the post-filter 138 are of a bayonet-type coupled to a header assembly manifold. Other types of port assemblies known to those of ordinary skill int he art can also be used with the invention.

An elastic bladder storage tank 136 as described above for the Single Pass Post-Filter System is used with the invention. Other types of storage tanks known

to those of ordinary skill in the art can also be used with the invention, however.

In embodiments of the invention, the system 130 can include an overall system output valve for varying fluid passing therethrough from the first port 172 of the post-filter 138 to the point of use.

C. Twin Post-Filter System

The invention provides, in another embodiment, a water treatment and storage system 210, such as a Twin Post-Filter System, as illustrated in FIGS. 8 and 9. The system 210 includes a pre-filter 212, an intermediate-filter 214, a storage tank 216 and a post filter 218, as shown in FIG. 8. Incoming fluid 220 is filtered through the pre-filter 212 and exits as output stream 222. The output stream 222 then inters the intermediate-filter 214 where it is further treated and the effluent stream 224 from the intermediate-filter 214 passes into a first post-filter sub-unit 218. The fluid is filtered through the first post-filter sub-unit 218 and exits as output stream 226. The output stream 225 passes into a fluid storage tank 216 where it may be held for variable lengths of time. The effluent 226 stream from the fluid storage tank 216 passes into a second post-filter sub-unit 219 for further treatment. Effluent 228 from the second post-filter sub-unit 219 then exits the system 210 to its point of use.

Accordingly, the Twin Post-Filter System 210 allows fluid 224 exiting the intermediate filter 214 to pass through the first post-filter sub-unit 218 at least once before entering the storage tank 216 and similarly allows fluid 226 exiting the storage tank 216 to make another pass through the second post-filter sub-unit 219 before exiting the system 210. Such a Twin Post-Filter System can be operated continuously.

A more detailed illustration of a Twin Post-Filter System 230 is illustrated in FIG. 9. In FIG. 9, incoming fluid 240 passes into a pre-filter 232 through an input port 252. The fluid is filtered through a pre-filter filter medium 256 to an output port 254. The filtered fluid stream 242 exits the pre-filter 232 through the output port 254 and passes into an intermediate-filter 234 through an input port 262. The fluid is filtered through an intermediate-filter filter medium 266 to an output port 264. The filtered fluid stream 244 exits the intermediate-filter 234

through the output port 264 and passes into a first post-filter sub-unit 238 through a first port 272. The fluid is filtered through the post-filter filter medium 276 and the filtered fluid 246 exits the first post-filter sub-unit 238 through a second port 274.

The effluent fluid 246 from the post-filter 238 passes into an interior region 294 of a fluid storage tank 236 though a storage tank fluid passage port 292 where it may be held for variable lengths of time. The fluid 247 exits the interior region 294 of the fluid storage tank 236 through the storage tank fluid passage port 292 and passes into a second post-filter sub-unit 239 through a first port 275. The fluid is filtered again through the post-filter filter medium 278 and the filtered fluid 248 exits the second post-filter sub-unit 239 through the second port 277. The effluent stream 248 from the second post-filter sub-unit 238 passes from the system 230 to its point of use.

Either one or a combination of the filter mediums 256, 266, 276, and 278 of the respective pre-filter 232, intermediate-filter 234, first post-filter sub-unit 238 and second post-filter sub-unit 239 include a filter medium impregnated with a bacteria limiting material. For example, such a medium can include activated carbon in either a granulated or a microporous solid block extruded form. Preferably, the filter medium, such as, for example, activated carbon is adapted to remove from water flowing therethrough particles having sizes in the range from about 1 to about 1000 micrometers.

The filter mediums of the Twin Post-Filter System 230 can function to remove color, odor, and/or organics as outlined above in the discussion of filter mediums for the Single Pass Post-Filter System 30.

The bacteria limiting material contained in one or a combination of the pre-filter 232, intermediate-filter 234, first post-filter sub-unit 238 and second post-filter sub-unit 239 limits biological growth. FIG. 9 illustrates the pre-filter 232, the intermediate-filter 234, first post-filter sub-unit 238 and the second post-filter sub-unit 239 each containing a bacteria limiting material 282, 284, 286 and 288, respectively.

Non-limiting examples of bacteria limiting materials useful for the Twin

Post-Filter System 230 are described above for the Single Pass Post-Filter System 30. Preferably an oligo-dynamic metal, and even more preferably, silver is used as the bacteria limiting material, as described above for the Single Pass Post-Filter System 30.

In addition to or in lieu of activated carbon, the filter medium 266 of the intermediate-filter 234 can include one or more of the membranes, microporous ceramic blocks, and/or sorbents described above for the Single Pass Post-Filter System 30.

In embodiments of the invention, the filter medium 266 of the intermediate filter 234 includes one or a combination of first and second filter components, as described above for the Single Pass Post-Filter System 30.

Preferably, each pre-filter 232, intermediate-filter 234, first post-filter sub-unit and second post-filter sub-unit 239 is replaced as a unit or alternatively, one, two or three of the filters are replaceable as a unit, as described above for the Single Pass Post-Filter System 30. In other embodiments of the invention, one or a combination of the filter mediums 256, 266, 276 and 278 are contained in a removable container, again as described above for the Single Pass Post-Filter System 30.

The pre-filter 232, the intermediate-filter 234, the first post-filter sub-unit and the second post-filter sub-unit 239 are illustrated as cylindrical containers. Other shaped containers known to those or ordinary skill in the art are possible for use with the invention, however

The input ports 252, 262 and the output ports 254, 264 of the respective pre-filter 232 and the intermediate-filter 234, and the first ports 272, 275 and the second ports 274, 277 port of the respective first post-filter sub-unit 238 and second post-filter sub-unit 239 are of a bayonet-type coupled to a header assembly manifold. Other types of port assemblies known to those of ordinary skill in the art can also be used with the invention.

An elastic bladder storage tank 236 as described above for the Single Pass Post-Filter System is used with the invention. Other types of storage tanks known to those of ordinary skill in the art can also be used with the invention, however.

filter component 324 is selected from the group consisting of microporous carbon filtration blocks, granular activated carbon, ultrafiltration membranes, nanofiltration membranes, reverse osmosis membranes, microfiltration membranes, microporous ceramic filtration blocks, chelating cation exchange resins, strong acid cation exchange resins, weak acid cation exchange resins, strong base anion exchange resins, weak base anion exchange resins, macroporous anion exchange resins, iodinated resins, granular absorbents and specialized lead removal media. Non-limiting examples of such microporous carbon filtration blocks, granular activated carbon, membranes, microporous ceramic filtration blocks, resins, absorbents and media are provided above in the description of the Single Pass Post-Filter System 30.

The second filter component 324 can also include a bacteria limiting material 326, as described above for the Single Pass Post-Filter System 30 and for the first cartridge. For example, the first filter component can contain silver, as described above for the first cartridge 312 of the Two Cartridge System 310.

Where the second filter component 324, such as, for example, a nanofiltration membrane or a reverse osmosis membrane, removes some of the bacteria limiting material from the water, the water downstream of the second filter component 324 may be susceptible to further growth of microorganisms. In such an event, the second cartridge 324 can include a third filter component 328, such as, for example, activated carbon in granular or in extruded microporous block form impregnated with a bacteria limiting material to limit biological growth downstream of the second filter component 324. Non-limiting examples of suitable bacteria limiting materials 330 are provided above in, for example, the description of the first cartridge 312 and in the description of the Single Pass Post-Filter System 30.

Each one or a combination of the cartridges 312, 320, depth filter 314, and filter components 316, 324, 328 can be replaceable as described above for the Single Pass Post-Filter System. Preferably, each of the cartridges 312, 320 is replaceable.

III. Water Polishing Systems Employing Graded Density Filtration Media Layers

The invention also provides water polishing systems employing filter devices including more than one graded density filtration medium layers. Such systems include a primary or first layer having a first filtration media being impregnated with a bacteria limiting material. The systems also include at least one additional second layer having a second filtration media for treating the water passing therethrough partially or substantially to remove minerals, TDS and/or other physical-chemical contaminants from the treated water.

The first layer of impregnated first filtration media is of a selected density such that it separates from the second layer of second filtration media during a backwash cycle and layers on top of the second layer without intermixing. The first filtration media releases the bacteria limiting material throughout the first and second layers to limit biological growth in the system. The bacteria limiting material can be removed and/or replaced through the control valve for the filter device. The density separation of the two filtration media allows the mass transfer zone of the bacteria limiting material to remain substantially intact and uninterrupted while the water passes therethrough. In addition, other treatments such as catalytic dechlorination and taste and odor removal can be accomplished by one or both of the first and second layers.

A closed loop system, a water storage and treatment system and a drinking water polishing system employing graded density filtration media layers are described below.

A. Closed Loop System

In still another embodiment, the invention provides a water polishing system 410 for a closed loop system 412 such as a recirculating loop in a building heating and cooling system, as illustrated in FIG. 11. The water polishing system 410 includes a multimedia filtration tank 414 containing different granulated media, each with its own specific gravity and dedicated function. Densities of each layer of media increase by the layer downwards. Partial flow from the closed loop system is fed through a flow control valve 416 into the upper or first media layer 418 of the tank 414 and the water filters downwards though the different media

layers. Treated water having passed through the media layers is discharged at the lower area 420 of the tank and returned via a flow control valve 422 to the closed loop system 412.

The individual granulated materials of each of the media layers may be washed clean of sludge and corrosion particles, etc. by directing a water flow in the upper direction from the bottom of the tank (i.e., in a backwash cycle) in a counter current mode to the normal downward process flow. The individual granulated media settle as the backwash cycle is finished into their respective layers because of their mutually differing density.

In the prior art, the layers of media are typically made up of filtration media 424 and active reaction media 426. The layer or layers of filtration media 424 typically remove particular matter larger than about 20 microns.

Layer or layers of active reaction media 426 increase the alkalinity and pH of the water passing therethrough. Thus, the active reaction media treatment increases the alkalinity and pH of the water in the closed loop system and establishes a chemical balance in the water such that the water is not corrosive to water pipes, fittings, valves, or other in-line controlling systems. Other media layer or layers 428 in the tank isolate the chemically active filter masses as required. The final or bottom media layer 430 is composed of glass spheres which isolate or create a chemically neutral surrounding for a zinc electrode which acts as a corrosion indicator. The positioning of media layer 424 on top of media layer 426 which is in turn on top of media layer 428 is drawn for illustrative purposes only. The actual positioning of the media layers depend upon the relative media densities, as discussed above.

Typically, active reaction media may consist of granulated magnesium oxide in which the pH of the water passing therethrough is upgraded according to the following chemical reaction:

$$MgO + H20 - Mg2+ + 2\,OH-$$

(OH- increases the pH value)

Alternatively, typical active reaction media may consist of granulated calcium carbonate in the form of crushed marble (CaCO3). The water passing

therethrough is then upgraded according to the following chemical reaction:

$CO2 + H2O - H2CO3$

$CaCO3 + H2O3 - CA{+}{+} + 2HCO3-$

(HCO3- further increases the pH)

In an embodiment of the invention, the first layer of media includes a filtration media 418 containing a bacteria limiting material 432, as described above in the Single Pass Post-Filter System. Preferably, the bacteria limiting material is an oligo-dynamic metal. More preferably, the oligo-dynamic metal is silver. Preferably, the filtration media includes granulated activated carbon. A non-limiting example of a silvered carbon filtration media is Hygene ® made by Ionics, Incorporated, Bridgeville, Pennsylvania. Preferably, the silvered carbon used in the invention contains between about .01% to about 10% carbon. The silver ions or other bacteria limiting material limits the growth of microorganisms which are in the water or have been captured by the carbon.

Preferably, the filtration media containing the bacteria limiting material, such as, for example, the silvered granular activated carbon discussed above, is selected to be of a density such that it separates from the underlying media during the backwash and lies on top of the other media layers when the backwash is completed.

In a more preferable embodiment of the invention, the first layer of filtration media containing the bacteria limiting material is selected to remove particulate matter having sizes greater than about 20 microns. As such, the filtration media filters substantially the most commonly occurring corrosion and sludge particles which are inherent in closed loop water-based recirculating heating and cooling systems.

B. Water Treatment and Storage Systems

One or a combination of the pre-filter, intermediate-filter and the post-filter of the water and treatment storage systems described above can also employ more than one layers of graded density filtration media. FIG. 12 shows an exemplary intermediate-filter including a filter medium having three layers of graded density filtration media. The first layer includes a silver impregnated filter media. The

second layer includes a cation softening resin and the third layer include a cation softening resin support media.

C. Drinking Water Polishing Systems

One or a combination of the cartridges of the drinking water polishing systems described above can also employ more than one layer of graded density filtration media.

This invention is further illustrated by the following Examples which should not be construed as limiting.

EXAMPLE I: Testing of Water Polishing Systems Each Including A Pre-Filter, an Intermediate-Filter and a Post-Filter

In this example, three water polishing systems each including a pre-filter containing a graded density filter medium for the removal of dirt oxidized iron and sediment; an intermediate-filter containing a reverse osmosis/ultrafiltration membrane for the substantial removal of minerals; and a post-filter containing a silver impregnated activated carbon filter (i.e., Hygene ® filters made by Ionics, Incorporated, Bridgeville, Pennsylvania) for limiting biological growth within the water passing therethrough and the carbon, and for controlling the taste and odor causing chemicals, such as, for example, chlorine, which may have been present in the water, were tested. Following each of the three-filter system was a 2.6 gallon storage tank.

The three filters of each of the water polishing systems were mounted on a wall bracket as one complete assembly. The water tested was municipally treated tap water. The storage tanks, water lines and faucets were sanitized in accordance with the installation instructions. Service water under pressure was allowed to enter each filter. Flow rates were measured and found to be approximately 24 milliliters/minute through each system. The storage tanks were allowed to fill overnight and emptied the following morning as an initial flush before recording test data.

Testing began August 8, 1985 and continued until all three of the water polishing systems were challenged with 1000 gallons of water. Samples were

collected and tested in accordance with US EPA test protocol.

Table I shows the time schedule for when samples of effluent water were taken from each of the three water polishing systems.

Table II shows the amount of silver present in the influent and effluent of each of the water polishing systems tested (i.e., Test Units #1, #2, and #3) at the start of testing and after 50 cumulative gallons (corresponding to 5% filter life), 500 cumulative gallons (corresponding to 50% filter life) and 1000 gallons (corresponding to 100% filter life) of water had been treated. The test results show that silver concentrations of the effluent were all under the Environmental Protection Agency's National Drinking Water Standard of 0.1 milligrams/liter.

Table III shows for each of the water polishing systems tested (i.e., Test Units #1, #2, and #3), the temperature, pH, hardness, alkalinity, TDS and free chlorine of the influent and effluent water at the start of testing and after 50 cumulative gallons (corresponding to 5% filter life), 500 cumulative gallons (corresponding to 50% filter life) and 1000 gallons (corresponding to 100% filter life) of water had been treated.

TABLE I

TEST TIME SCHEDULE

DATE	TIME	GALLONS	% LIFE	NOTES
08-07-95	8:00 AM	0	0	1
08-07-95	4:30 PM	2.5		2
08-22-95	8:00 AM	50	5%	3
08-23-95	8:00 AM	50		4
01-19-96	4:30 AM	500	50%	5
01-22-96	8:00 AM	500		6
06-18-96	4:30 PM	1000	100%	7
06-19-96	4:30 PM	1000		8

NOTES:

(1) Start

(2) First effluent sample collected for silver release (Table II) and test conditions (Table III)

(3) Stop flow at 5% of filter life for 24 hour hold

(4) Collected samples for silver release and test conditions

(5) Stop at 50% of filter life for 24 hour hold

(6) Collected samples for silver release and test conditions

(7) Stop flow at 100% of filter life for a 24 hour hold

(8) Collected samples for silver release and test conditions.

TABLE II

SILVER RELEASE DATA

SCHEDULE	DATE	TIME	SILVER RELEASE *ppb	
			INFLUENT	EFFLUENT
Start First Effluent:				
Test Unit #1	08-07-95	4:30 PM	<5	25
Test Unit #2	08-07-95	4:30 PM		32
Test Unit #3	08-07-95	4:30 PM		30
5% Filter Life-50 Gal.				
Test Unit #1	08-23-95	4:30 AM		28
Test Unit #2	08-23-95	8:00 AM		30
Test Unit #3	08-23-95	8:00 AM		33
50% Filter Life-500 Gal.				
Test Unit #1	01-22-96	8:00 AM	<5	22
Test Unit #2	01-22-96	8:00 AM		26
Test Unit #3	01-22-96	8:00 AM		20
100% Filter Life-1000				
Test Unit #1	06-19-96	4:30 PM	<5	15
Test Unit #2	06-19-96	4:30 PM		21
Test Unit #3	06-19-96	4:30 PM		17

* Chemical analysis for silver concentration performed by Atomic Absorption Method

TABLE III

RECORD OF TEST CONDITIONS

SCHEDULE		TEST UNIT NO.		
		1	2	3
0% Filter Life Date: 08-07-95 Water Analysis Time: 4:30 p.m. Cumulative Gallons 0				
Temperature - °C	Influent	22	22	22
	Effluent	22	22	22
pH	Influent	7.5	7.5	7.5
	Effluent	7.0	6.9	6.9
Hardness ppm as $CaCO_3$	Influent	145	145	145
	Effluent	12	10	10
Alkalinity ppm as $CaCO_3$	Influent	30	30	30
	Effluent	4	4	4
Total Dissolved Solids (Calculated) ppm as $CaCO_3$	Influent	213	213	213
	Effluent	18	18	18
Free Chlorine ppm as $C1_2$	Influent	0.55	0.55	0.55
	Effluent	0	0	0

TABLE III (continued)

RECORD OF TEST CONDITIONS

SCHEDULE		TEST UNIT NO. 1	2	3
5% Filter Life Date: 08-23-95 Water Analysis Time: 8:00 A.M. Cumulative Gallons 50				
Temperature - °C	Influent	22	22	22
	Effluent	22	22	22
pH	Influent	7.4	7.4	7.4
	Effluent	7.0	6.8	6.8
Hardness ppm as $CaCO_3$	Influent	136	136	136
	Effluent	10	10	10
Alkalinity ppm as $CaCO_3$	Influent	24	24	24
	Effluent	4	4	4
Total Dissolved Solids (Calculated) ppm as $CaCO_3$	Influent	177	177	177
	Effluent	15	15	15
Free Chlorine ppm as Cl_2	Influent	0.75	0.75	0.75
	Effluent	0	0	0

TABLE III (continued)

RECORD OF TEST CONDITIONS

SCHEDULE		TEST UNIT NO.		
		1	2	3
50% Filter Life Date: 01-22-96 Water Analysis Time: 8:00 A.M. Cumulative Gallons 500				
Temperature - °C	Influent	18	18	18
	Effluent	20	20	20
pH	Influent	7.7	7.7	7.7
	Effluent	7.0	7.0	7.2
Hardness	Influent	158	158	158
ppm as $CaCO_3$	Effluent	10	12	12
Alkalinity	Influent	32	32	32
ppm as $CaCO_3$	Effluent	6	6	6
Total Dissolved	Influent	228	228	228
Solids (Calculated)	Effluent	20	20	18
ppm as $CaCO_3$				
Free Chlorine	Influent	0.4	0.4	0.4
ppm as Cl_2	Effluent	0.0	0.0	0.0

TABLE III (continued)

RECORD OF TEST CONDITIONS

SCHEDULE		TEST UNIT NO.		
		1	2	3
100% Filter Life Date: 06-19-96 Water Analysis Time: 4:30 P.M. Cumulative Gallons 1000				
Temperature - °C	Influent	20	20	20
	Effluent	20	20	20
pH	Influent	7.1	7.1	7.1
	Effluent	6.7	6.7	6.7
Hardness	Influent	97	97	97
ppm as $CaCO_3$	Effluent	10	10	8
Alkalinity	Influent	16	16	16
ppm as $CaCO_3$	Effluent	6	6	4
Total Dissolved	Influent	144	144	144
Solids (Calculated)	Effluent	16	16	16
ppm as $CaCO_3$				
Free Chlorine	Influent	0.80	0.80	0.80
ppm as Cl_2	Effluent	0	0	0

Those of skill in the art will recognize that the invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The presently described embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all variations of the invention which are encompassed within the meaning and range of equivalency of the claims are therefor intended to be embraced therein.

What is claimed is:

1. A water treatment and storage system comprising:

a pre-filter having an input port and an output port fluidly coupled by way of a pre-filter filter medium;

an intermediate-filter having an input port and an output port fluidly coupled by way of an intermediate-filter filter medium;

a post-filter having a first port and a second port fluidly coupled by way of a post-filter filter medium;

wherein the pre-filter, the intermediate-filter, and the post-filter are coupled together such that there is a system fluid flow path passing through the pre-filter, the intermediate filter and the post-filter, and exiting through the second port of the post-filter; and

a fluid storage tank having an interior region of the tank and a bi-directional fluid passage port fluidly coupled between the interior region of the tank, the output port of the intermediate-filter and the second port of the post-filter, and

wherein at least one of the pre-filter filter medium, the intermediate-filter filter medium, and the post-filter filter medium contain a bacteria limiting material.

2. A water treatment and storage system according to claim 1 wherein the intermediate-filter, the post-filter and the storage tank are fluidly coupled together such that the system flowpath passes from the output port of the intermediate-filter through the storage tank fluid passage port to and subsequently from the interior region of the fluid storage tank, the first port of the post filter and the post-filter filter medium, and exits through the second port of the post-filter.

3. A water treatment and storage system according to claim 1 wherein the intermediate filter, the post-filter and the storage tank are fluidly coupled together such that the system flowpath passes from output port of the intermediate-filter through the second port of the post-filter, the post-filter medium, the first port of the post-filter, the storage tank fluid passage port to and subsequently from the interior region of the fluid storage tank, the first port of the post-filter and the post-filter filter medium, and exits through the second port of the post-filter.

4. A water treatment and storage system according to claim 1 wherein the post-filter further comprises

a first post-filter sub-unit having a first sub-port and a second sub-port fluidly coupled by way of a first post-filter sub-unit filter medium;

a second post-filter sub-unit having a first sub-port and a second sub-port fluidly coupled by way of a second post-filter sub-unit filter medium,

wherein the intermediate-filter, the first post-filter sub-unit, the second post-filter sub-unit and the storage tank are fluidly coupled together such that the system flowpath passes from the output port of the intermediate-filter through the first sub-port of the first post-filter sub-unit, the first post-filter sub-unit filter medium, the second sub-port of the first post-filter sub-unit, the storage tank fluid passage port to and subsequently from the interior region of the fluid storage tank, the first sub-port of the second post-filter sub-unit and the second post-filter sub-unit filter medium, and exits through the second sub-port of the second post-filter sub-unit.

5. A drinking water polishing system comprising at least two water treatment units, each unit comprising a base and a replaceable cartridge, the replaceable cartridge of a first unit comprising a depth filter adapted to remove from water flowing therethrough particles having sizes in the range from about 1 to about 1000 micrometers and down-stream from said depth filter in said cartridge, silvered, granular, activated carbon characterized by releasing into water flowing therethrough soluble silver in the range from about 5 to about 90 micrograms per liter, and down-stream from said first unit, at least one additional unit, a replaceable cartridge thereof comprising at least one component selected from the group of components consisting of;

microporous carbon filtration blocks, silvered microporous carbon filtration blocks, granular activated carbon, silvered granular activated carbon, ultrafiltration membranes, nanofiltration membranes, reverse osmosis membranes, microfiltration membranes, chelating cation exchange resin, strong acid cation exchange resin, weak acid cation exchange resin, strong base anion exchange resin, weak base anion exchange resin, macroporous anion exchange resin, granular absorbents, iodinated ion-exchange resin and specialized lead removal media.

6. A drinking water polishing system comprising

at least a first water treatment unit having a first cartridge and a base,

wherein the first cartridge has a depth filter adapted to remove from water flowing therethrough particles having sizes in a range from about 1 to about 1000 micrometers, and

wherein down-stream from the depth filter in the first cartridge, the first cartridge has a first component; and

at least a second water treatment unit having a second cartridge and a base,

wherein the second cartridge has at least one second filter component, and

wherein at one of the first and the second filter components is impregnated with a bacteria limiting material.

7. A drinking water polishing system according to claim 6 wherein the bacteria limiting material comprises a silver material.

8. A drinking water polishing system according to claim 7 wherein the first filter component comprises activated carbon adapted to release into water passing therethrough the silver material in a range of about 5 to about 90 micrograms per liter.

9. A drinking water polishing system according to claim 6 wherein the filter component is selected from the group of components consisting of;

microporous carbon filtration blocks, silvered microporous carbon filtration blocks, granular activated carbon, silvered granular activated carbon, ultrafiltration membranes, nanofiltration membranes, reverse osmosis membranes, microfiltration membranes, chelating cation exchange resin, strong acid cation exchange resin, weak acid cation exchange resin, strong base anion exchange resin, weak base anion exchange resin, macroporous anion exchange resin, granular absorbents, iodinated ion-exchange resin and specialized lead removal media.

10. A drinking water polishing system according to claim 6 wherein the first cartridge and the second cartridge are replaceable.

11. A method of treating and storing potable and process water comprising:

passing water through a pre-filter having an input port and an output port fluidly coupled by way of a pre-filter filter medium;

passing water through an intermediate-filter having an input port and an output port fluidly coupled by way of an intermediate-filter filter medium; and

passing water through a post-filter having a first port and a second port fluidly coupled by way of a post-filter filter medium,

wherein the pre-filter, the intermediate-filter, and the post-filter are coupled together such that there is a system fluid flow path passing through the pre-filter, the intermediate filter and the post-filter, and exiting through the second port of the post-filter; and

storing water in a fluid storage tank having an interior region of the tank and a bi-directional fluid passage port fluidly coupled between the interior region of the tank, the output port of the intermediate-filter and the second port of the post-filter,

wherein at least one of the pre-filter filter medium, the intermediate-filter filter medium, and the post-filter filter medium contains a bacteria limiting material.

FIG. 1.

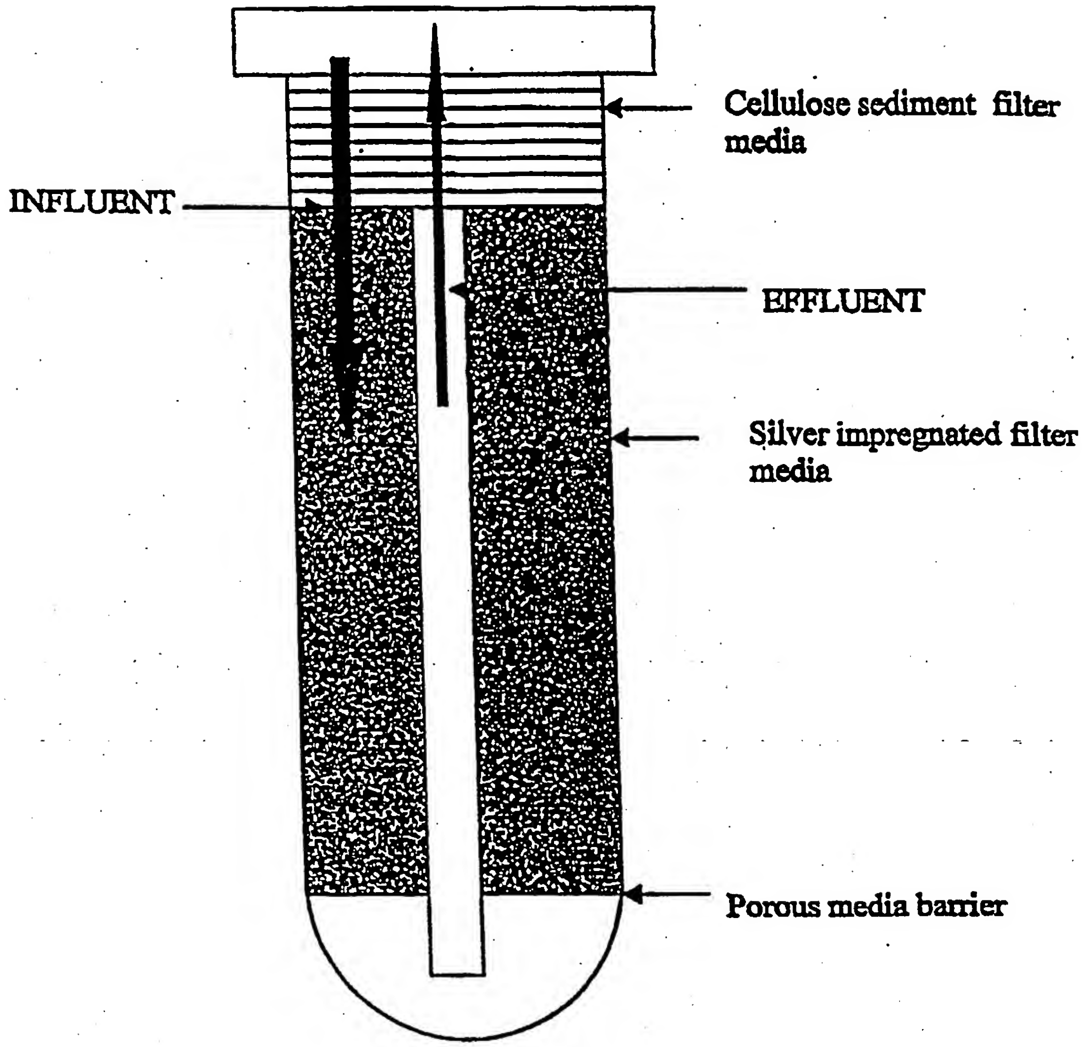

Cellulose sediment filter media
INFLUENT
EFFLUENT
Silver impregnated filter media
Porous media barrier

FIG. 2.

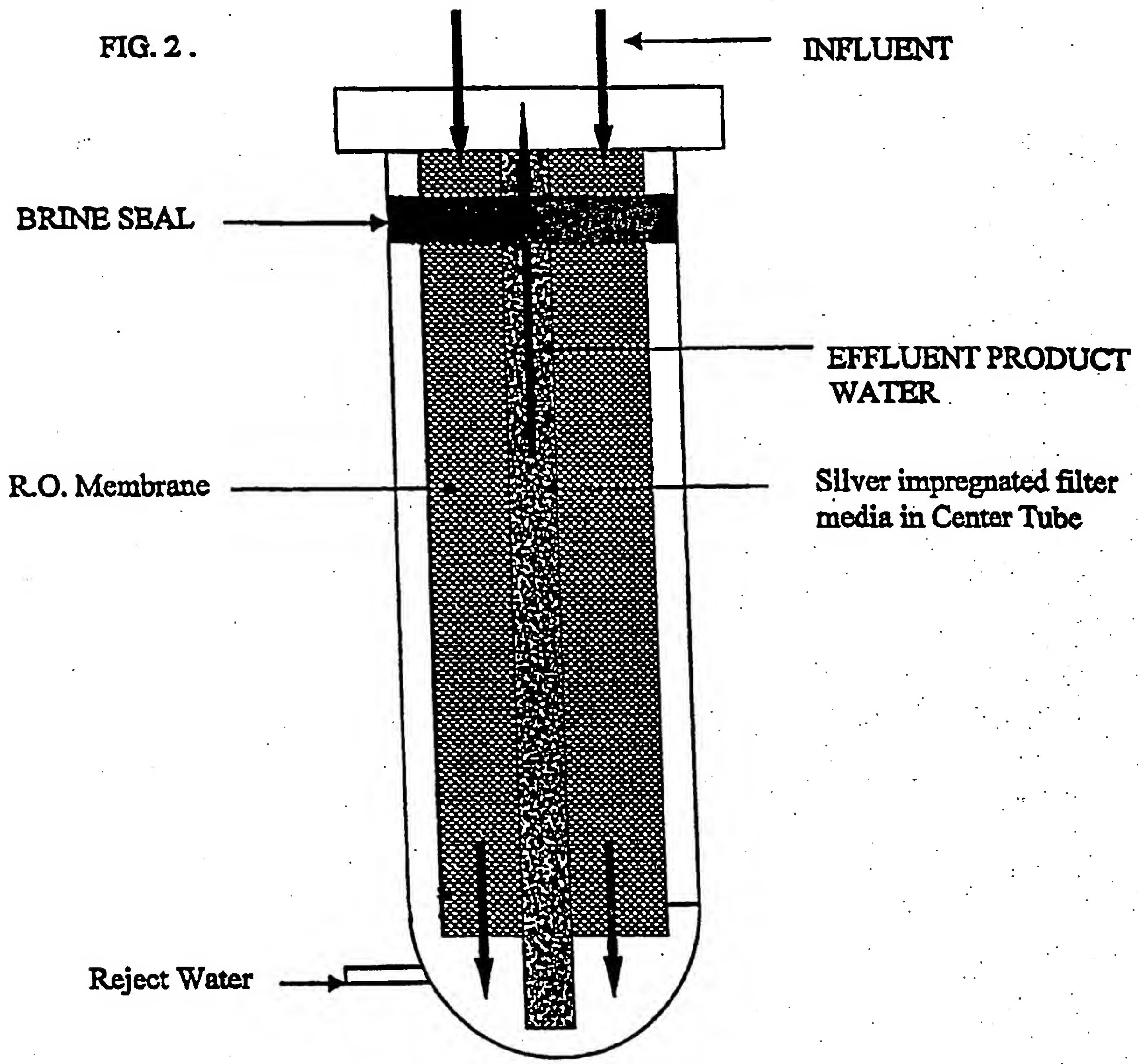

INFLUENT
BRINE SEAL
EFFLUENT PRODUCT WATER
R.O. Membrane
Silver impregnated filter media in Center Tube
Reject Water

FIG. 3.

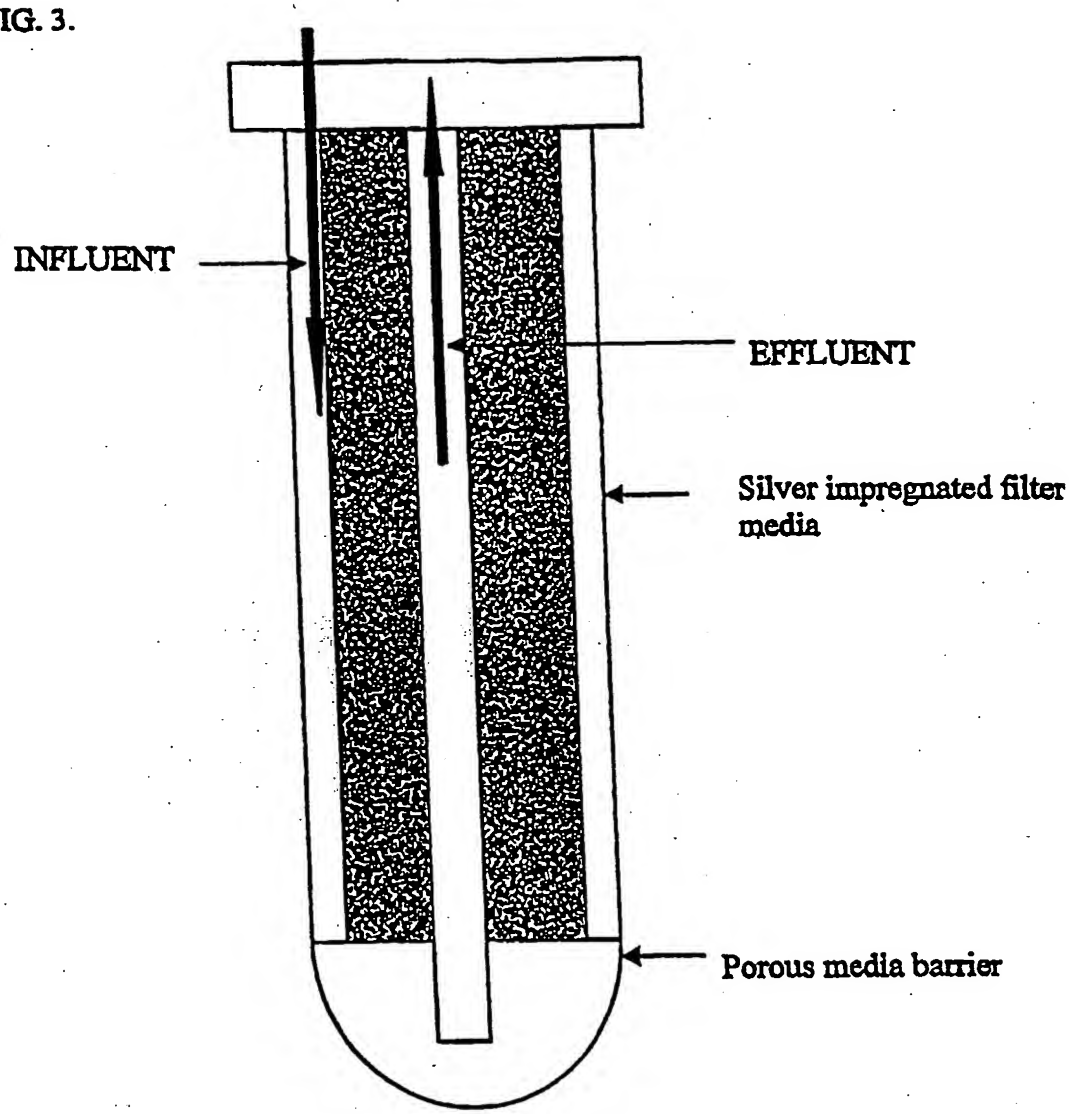
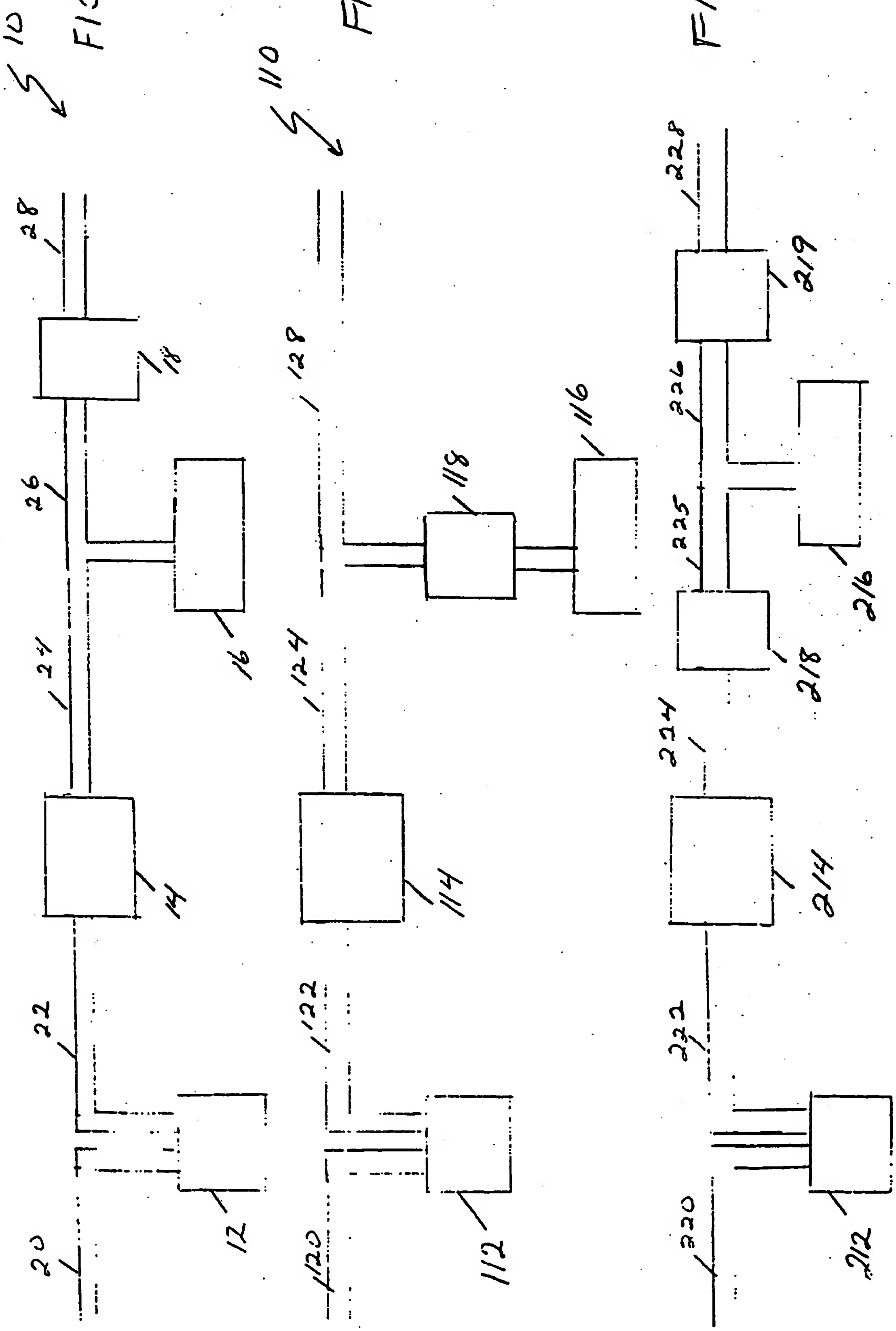

INFLUENT
EFFLUENT
Silver impregnated filter media
Porous media barrier

FIG. 4

FIG. 6

FIG. 8



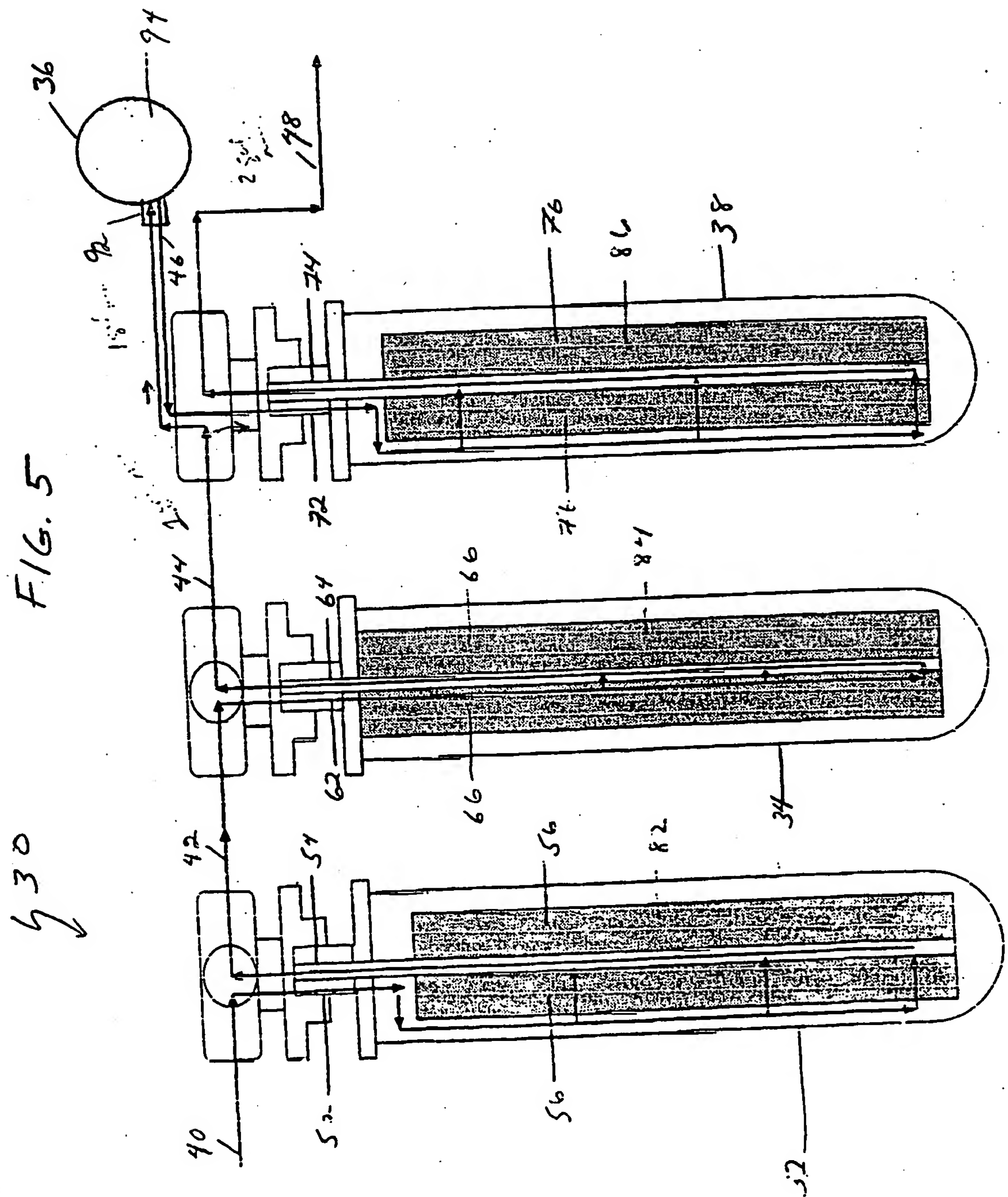


FIG. 5

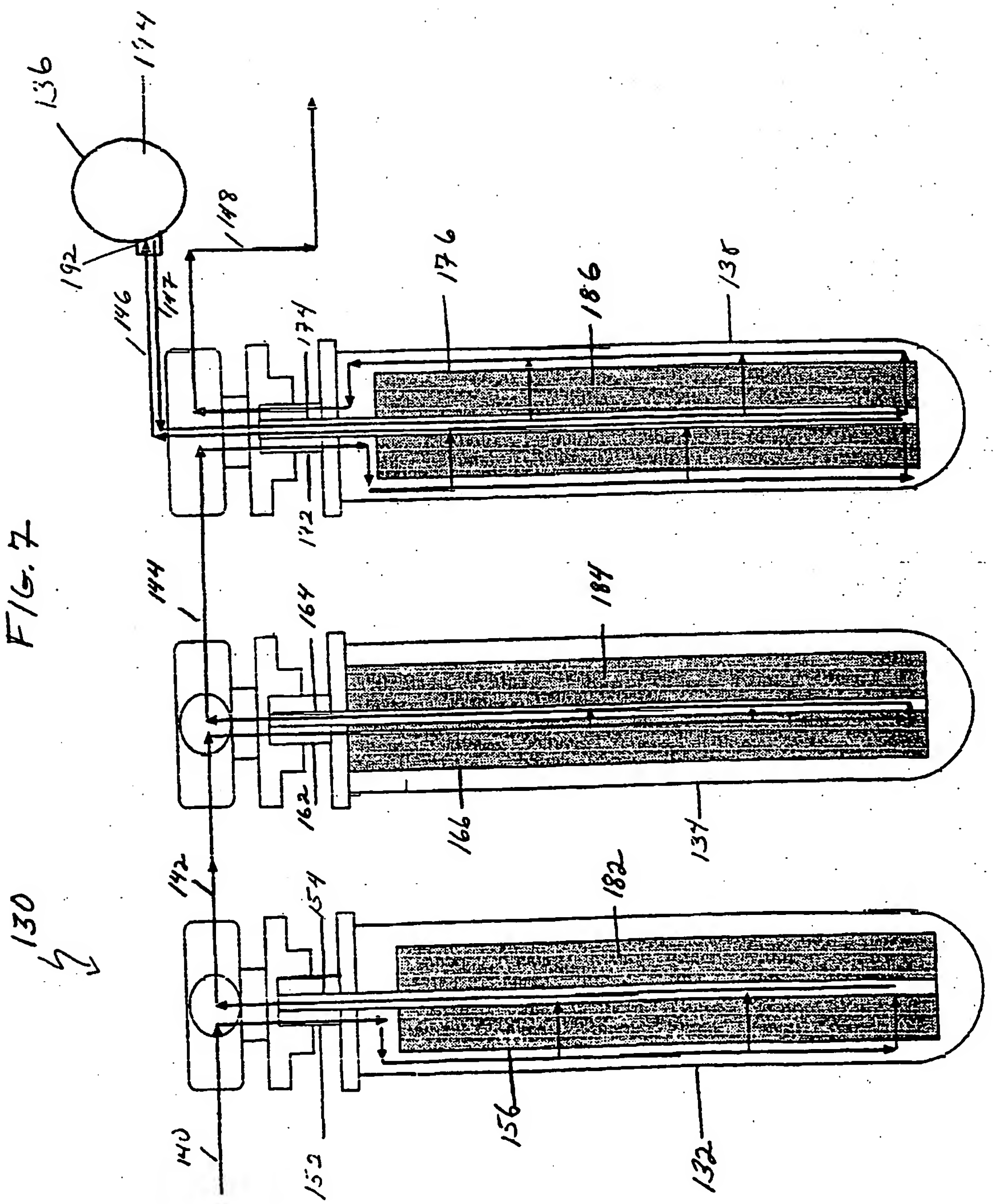

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FIG. 7

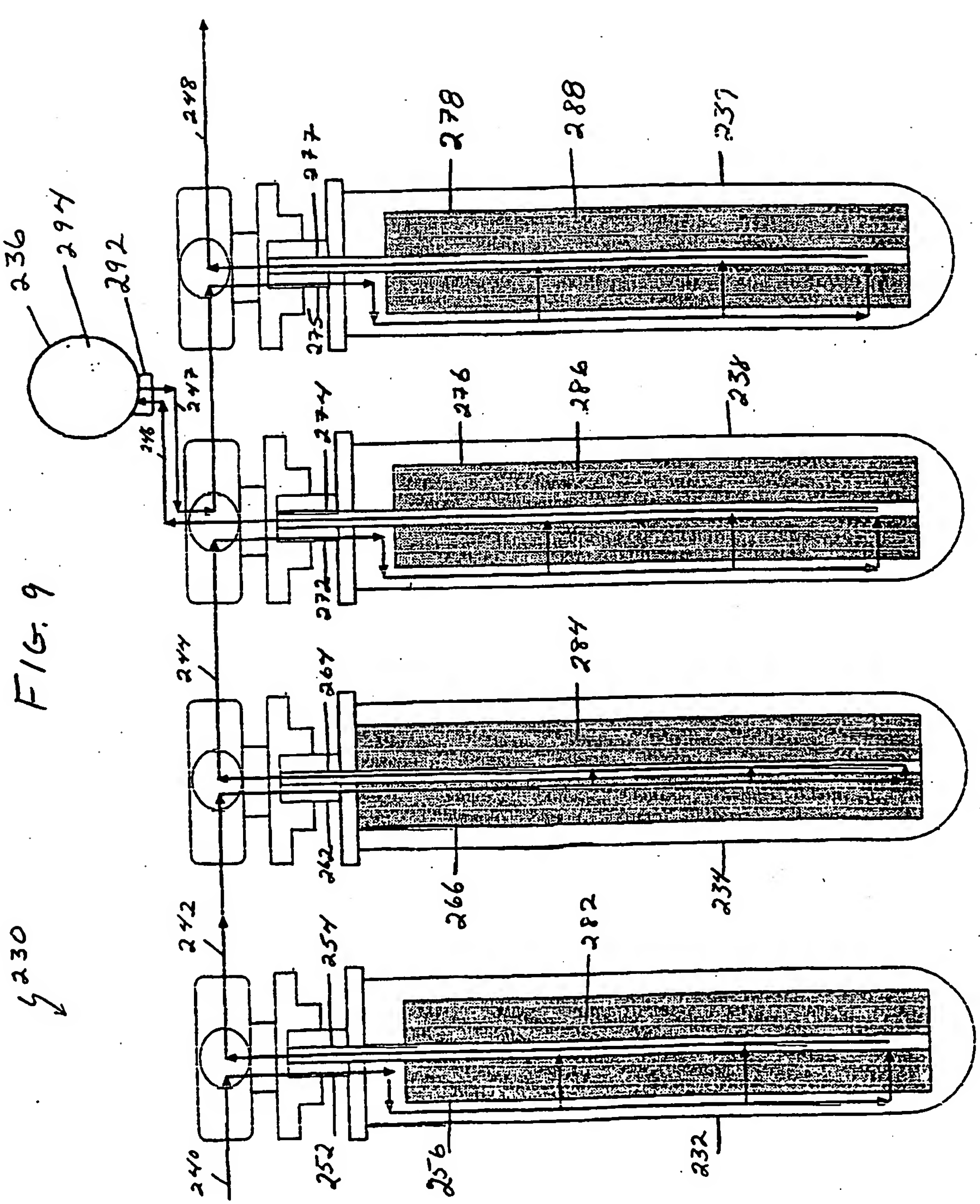
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FIG. 9

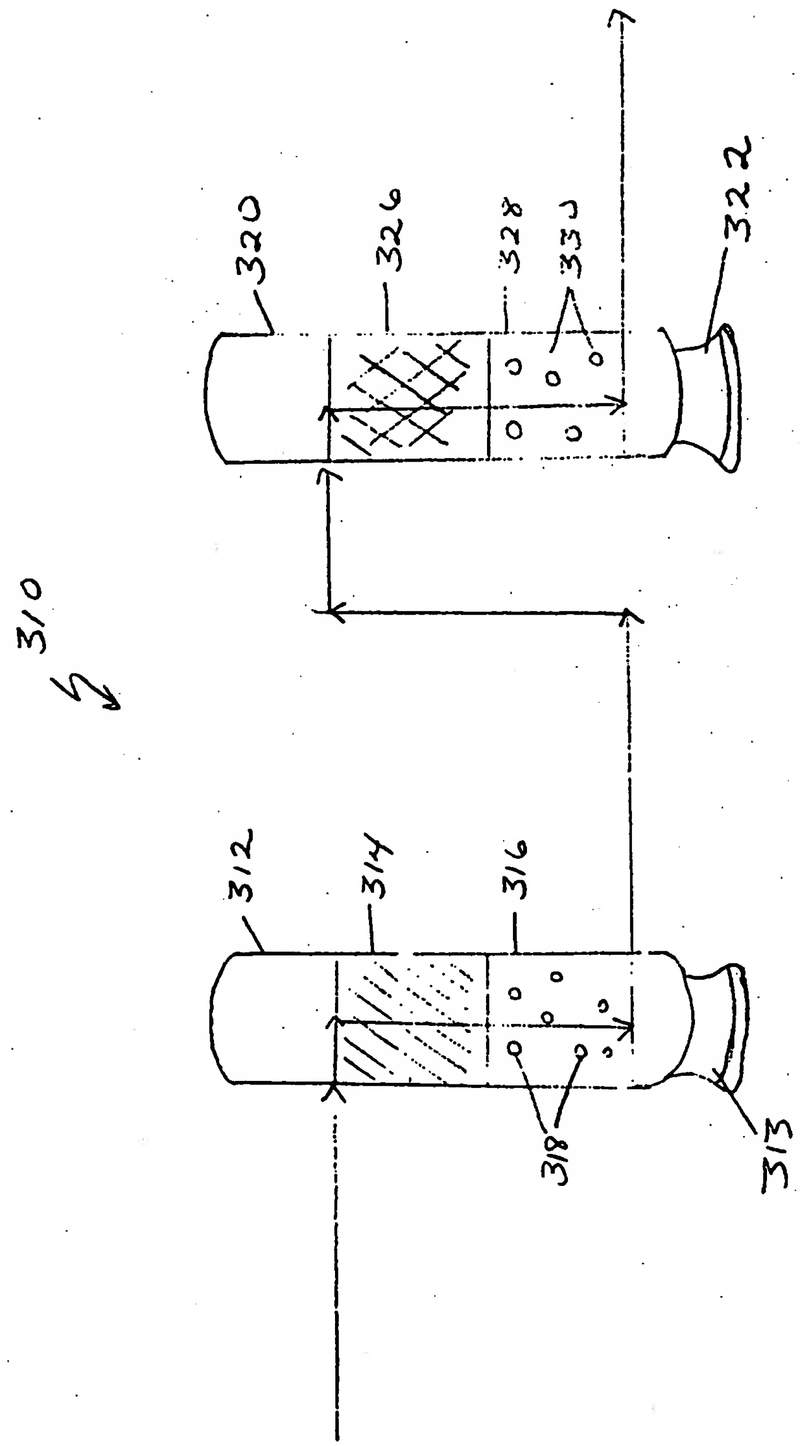


FIG. 10

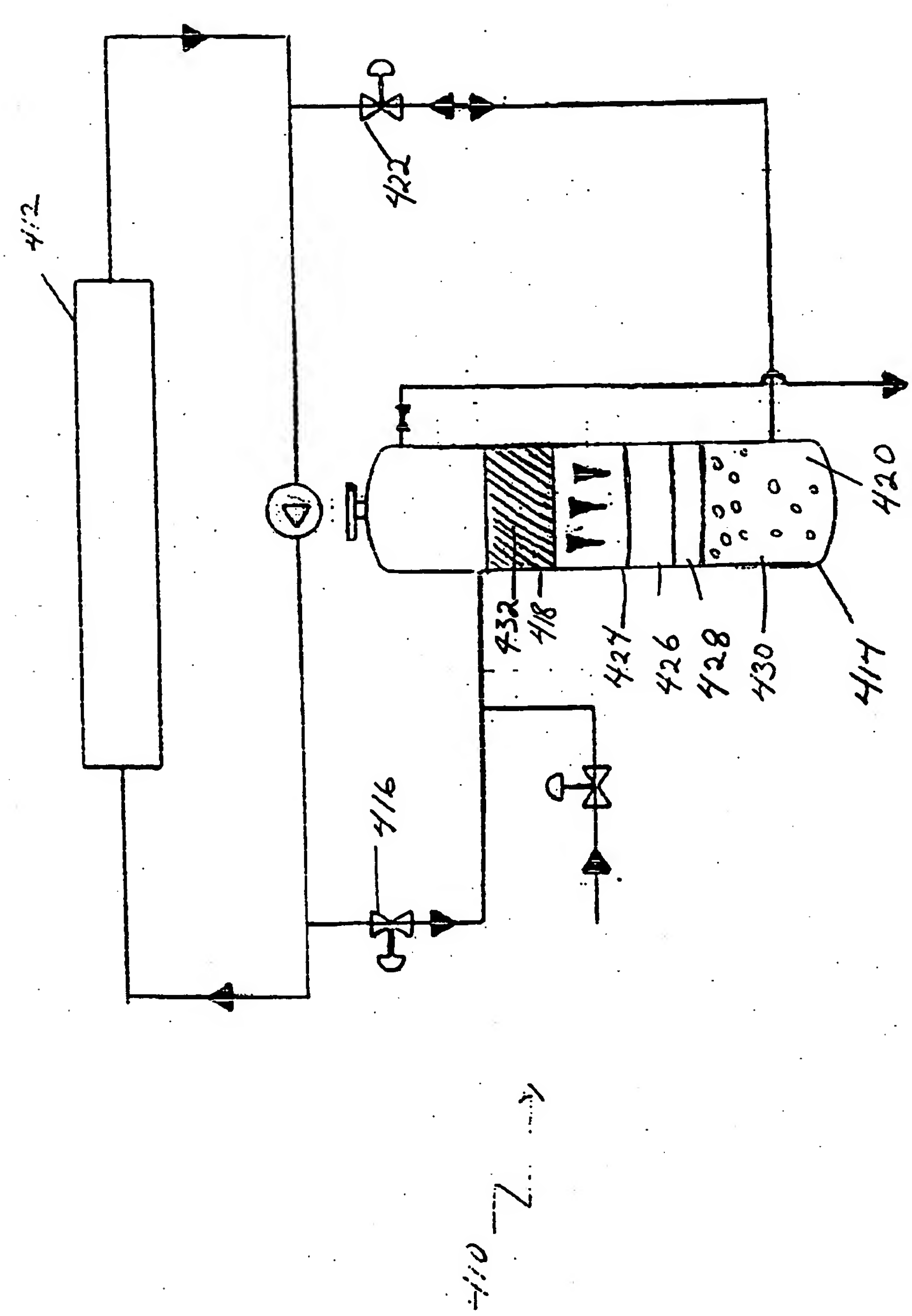
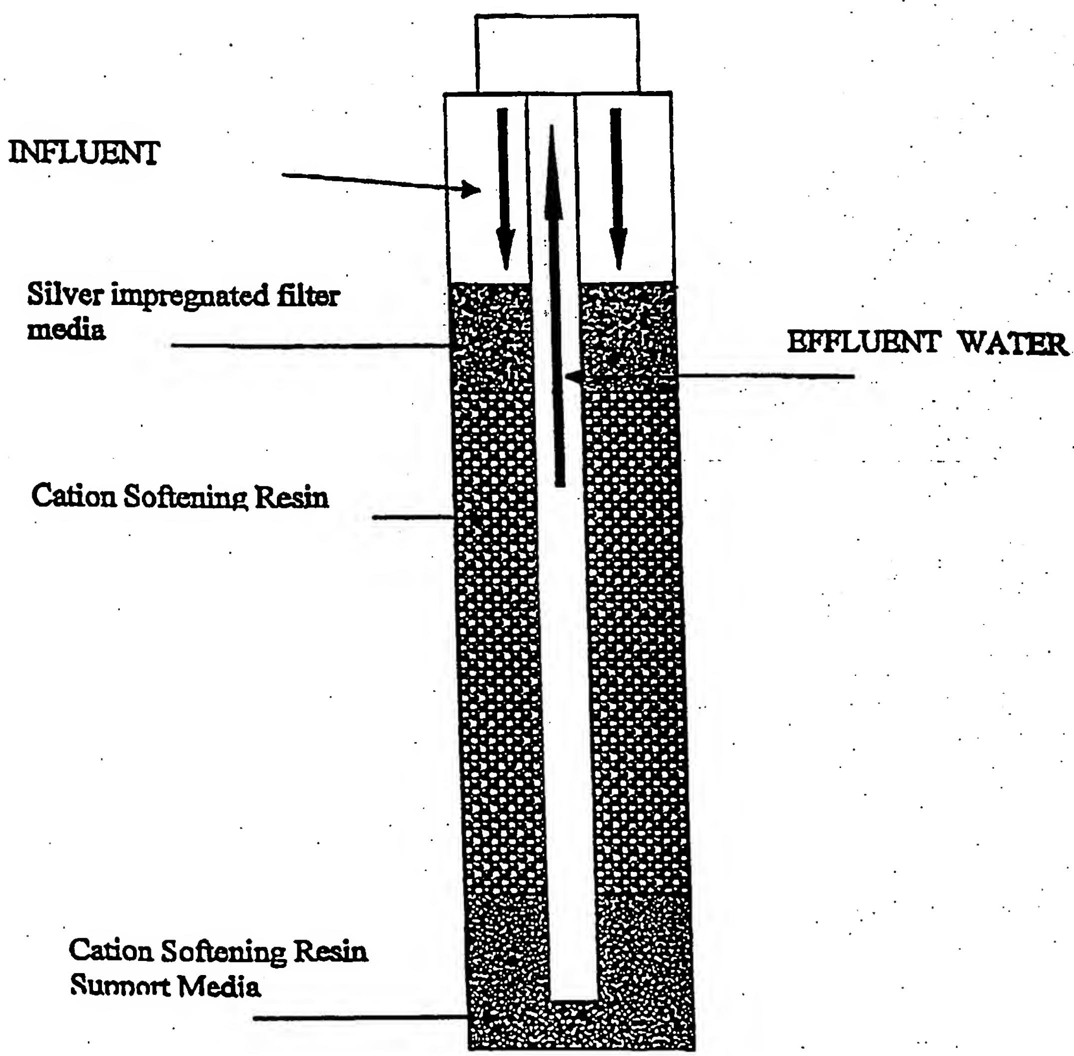


FIG. 11

FIG. 12


INFLUENT
Silver impregnated filter media
EFFLUENT WATER
Cation Softening Resin
Cation Softening Resin Support Media

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/05648

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :Please See Extra Sheet.
US CL : 210/257.1, 259, 435, 444, 501, 506
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 210/257.1, 259, 435, 444, 501, 506

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X — Y	US 4,713,175 A (BRAY) 15 December 1987, entire disclosure.	5-10 ------- 1-4, 11
Y,P	US 5,824,215 A (SUH) 20 October 1998, entire disclosure.	4
A	US 4,540,489 A (BARNARD) 10 September 1985, abstract and figure 1).	1-11
A	US 4,897,187 A (RICE) 30 January 1990, figure 1.	1-11
A,P	US 5,269,919 A (VON MEDLIN) 14 December 1993, figures 1-3.	1-11
A,P	US 5,741,420 A (SUH et al) 21 April 1998, figures 1 and 4.	1-11

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 MAY 1999	28 JUN 1999
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer MICHAEL FLEMING Telephone No. (703) 308-0661

Form PCT/ISA/210 (second sheet)(July 1992)★

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/05648

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,082,557 A (GRAYSON et al) 21 January 1992, figure 1.	1-11
Y	US 5,653,877 A (MARK) 05 August 1997, entire disclosure.	1-4, 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/05648

A. CLASSIFICATION OF SUBJECT MATTER:
IPC (6):

B01D 9/00, 24/00, 27/00, 35/00, 35/28, 39/08, 39/12, 39/14; C02F 9/00